SPACE STATION PROGRAMS

SPACE STATION

TRACE CONTAMINANT CONTROL

SPACE STATION PROGRAMS

SPACECABIN CONTAMINANT SOURCES

SOURCE	CONTAMINANT
o MAN	- METABOLIC PRODUCTS: CO_2, NH_3, CO, H_2S, H_2 CH_4, ORGANIC ACIDS, MERCAPTANS
	- BACTERIOLOGICAL CONTAMINANTS
o SPACECRAFT SUBSYSTEMS, EXPERIMENT EQUIPMENT AND PAYLOADS	- WIDE VARIETY OF ALCOHOLS, ALDEHYDES, AROMATICS, ESTERS, ETHERS, CHLOROCARBONS, FLUOROCARBONS, HALOCARBONS, HYDROCARBONS, KETONES, ACIDS
o EMERGENCY SITUATIONS: FIRE, SPILLS, EQUIPMENT FAILURES	- CO, CO_2, HYDROCARBONS, AROMATICS, ACID GASES, OXIDES OF N_2, SO_2, NH_3, ALCOHOLS, FORMALDEHYDE
o ANIMAL AND PLANT EXPERIMENTS	- METABOLIC, BACTERIOLOGICAL

SPACE STATION PROGRAMS

TECHNOLOGY BASE

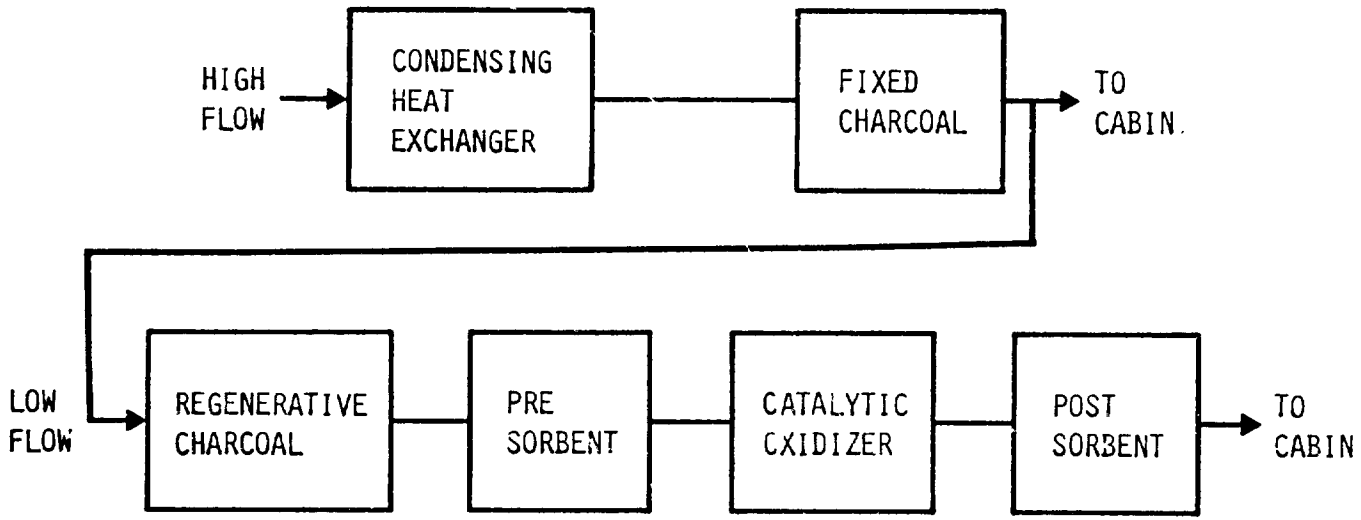
- DEFINITION OF ACTIVATED CHARCOAL SORPTION CHARACTERISTIC FOR A WIDE VARIETY OF CONTAMINANTS AND CHARCOALS
- DEVELOPMENT OF ANALYTICAL TOOLS FOR PREDICTING CHARCOAL SORPTION AND SIZING OF BED
- DEVELOPMENT OF IN-FLIGHT CHARCOAL BED REGENERATION METHODS USING HEAT AND VACUUM
- DEFINITION OF CONDENSING HEAT EXCHANGER REMOVAL CAPACITY
- DEFINITION OF HIGH TEMPERATURE CATALYTIC OXIDIZER PERFORMANCE CHARACTERISTICS AND PRE AND POST SORBENT REQUIREMENTS
- DEFINITION OF PRE AND POST SORBENT BED PERFORMANCE
- DEVELOPMENT OF ROOM TEMPERATURE CATALITIC OXIDIZER BED
- DEVELOPMENT OF ACID GAS REMOVAL BED
- DEVELOPMENT OF AMMONIA REMOVAL SORBENT
- DEVELOPMENT OF FORMALDEHYDE REMOVAL SORBENT

CONTAMINANT CONTROL SYSTEM ELEMENTS

DEVICE	CONTROLS
FIXED CHARCOAL BED	LOW MOLAR VOLUME WELL ABSORBED CONTAMINANTS
REGENERATIVE CHARCOAL BED	HIGH MOLAR VOLUME MODERATELY WELL ABSORBED CONTAMINANTS
PHOSPHORIC ACID IMPREGNATED CHARCOAL	AMMONIA
CONDENSING HEAT EXCHANGER	HIGHLY SOLUBLE CONTAMINANTS
ROOM TEMPERATURE CATALYTIC OXIDIZER	CARBON MONOXIDE, HYDROGEN
HIGH TEMPERATURE CATALYTIC OXIDIZER	POORLY ABSORBED HYDROCARBONS
PRE AND POST SORBENT	ACID GASSES, SULFUR COMPOUNDS

SPACE STATION PROGRAMS

TYPICAL CONTAMINANT CONTROL SYSTEM CONFIGURATION



SPACE STATION PROGRAMS

APPROACH TO CONTAMINANT CONTROL

- o DEFINE CONTAMINANT LOAD MODEL AND PRODUCTION RATES
- o DEFINE SPACECRAFT MAXIMUM ALLOWABLE CONCENTRATIONS (SMAC)
- o ESTABLISH FIXED CHARCOAL BED SIZE FOR EACH CONTAMINANT
- o DEFINE NEED FOR REGENERATIVE BED
- o DEFINE CONTAMINANTS NOT HANDLED BY FIXED AND REGENERATIVE BEDS
- o SIZE SPECIAL SORBENT BEDS OR CATALYTIC OXIDIZERS
- o OPTIMIZE SYSTEM CONSIDERING CONTAMINANT LOAD AND SYSTEM INTERACTION

SPACE STATION PROGRAMS

CONTAMINANT LOAD MODEL DEFINITION

DATA SOURCES

- o WSTF MATERIALS OFFGASSING TESTS
- o SPACE COMPONENTS OFFGASSING TESTS
- o PAYLOAD EQUIPMENT OFFGASSING TESTS
- o MANNED SPACECRAFT CONTAMINANT MONITORING (GROUND AND FLIGHT)
- o GROUND BASED MANNED SIMULATOR TESTS
- o LITERATURE AND TEST DATA FOR METABOLIC CONTAMINANTS

DATA COMPILATION

- o DETERMINATION OF PAYLOAD GENERATION RATES PER UNIT WEIGHT
- o ESTIMATE OF TOTAL PAYLOAD WEIGHT
- o DETERMINATION OF SPACE SYSTEMS GENERATION RATES PER UNIT WEIGHT
- o METABOLIC LOADS FROM CREW SIZE
- o COMPOSITE CONTAMINANT LOAD

SPACECRAFT MAXIMUM ALLOWABLE CONCENTRATIONS

- ESTABLISHED BY NASA JSC MEDICAL DIRECTORATE
- DOCUMENTED IN NHB 8060.113 FOR UP TO 7 DAYS
- SOME CONTAMINANTS NOT INCLUDED IN NHB 8060.113
- SEVERAL CONTAMINANTS HAVE VERY LOW ALLOWABLE LEVELS

CHARCOAL BED SIZING

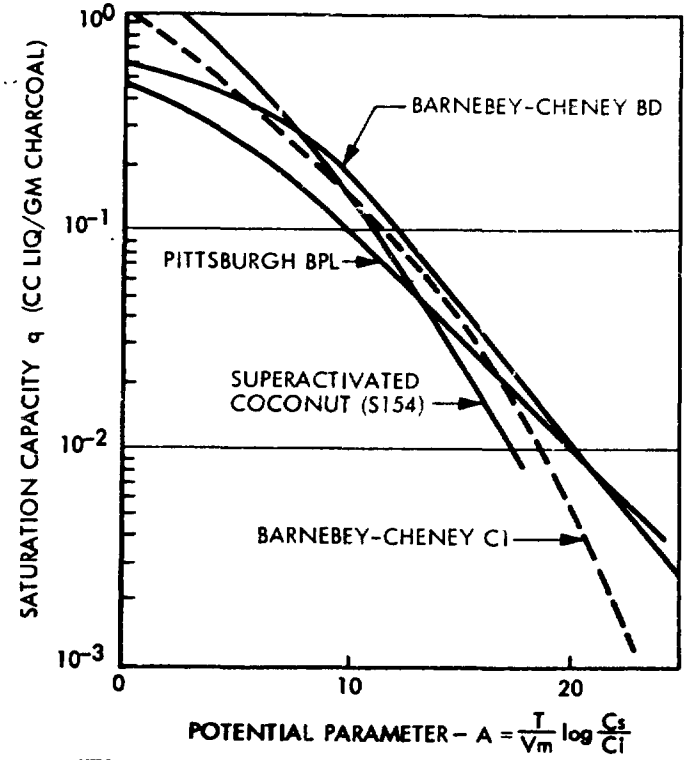
- CHARCOAL BED INCLUDES SATURATED ZONE PLUS ABSORPTION ZONE
- CAPACITY DEPENDS ON CONTAMINANT CHARACTERISTICS
  - TEMPERATURE
  - MOLAR VOLUME
  - VAPOR PRESSURE
  - INLET CONCENTRATION

  } "A" VALUE
- "A" VALUE PLUS EXPERIMENTALLY DETERMINED POTENTIAL PLOT PROVIDES SATURATION CAPACITY
- ADSORPTION ZONE LENGTH IS ADDED TO SATURATED ZONE TO DETERMINE TOTAL BED SIZE
- BED SIZE ADJUSTED FOR COADSORPTION
- SIZING ACCOMPLISHED BY COMPUTER PROGRAM (ICHAR)

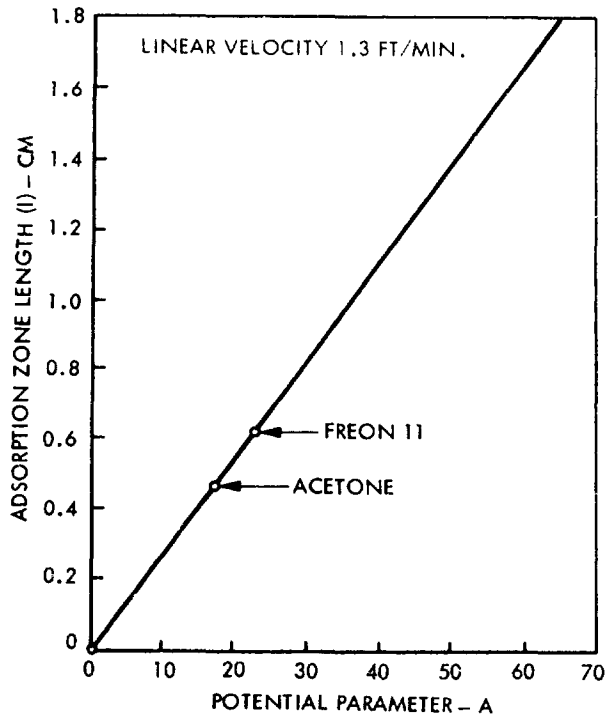
SPACE STATION PROGRAMS

TYPICAL CHARCOAL PERFORMANCE CHARACTERISTICS

POTENTIAL PLOT FOR VARIOUS CHARCOALS



ADSORPTION ZONE LENGTHS FOR VARIOUS CONTAMINANTS



SPACE STATION PROGRAMS

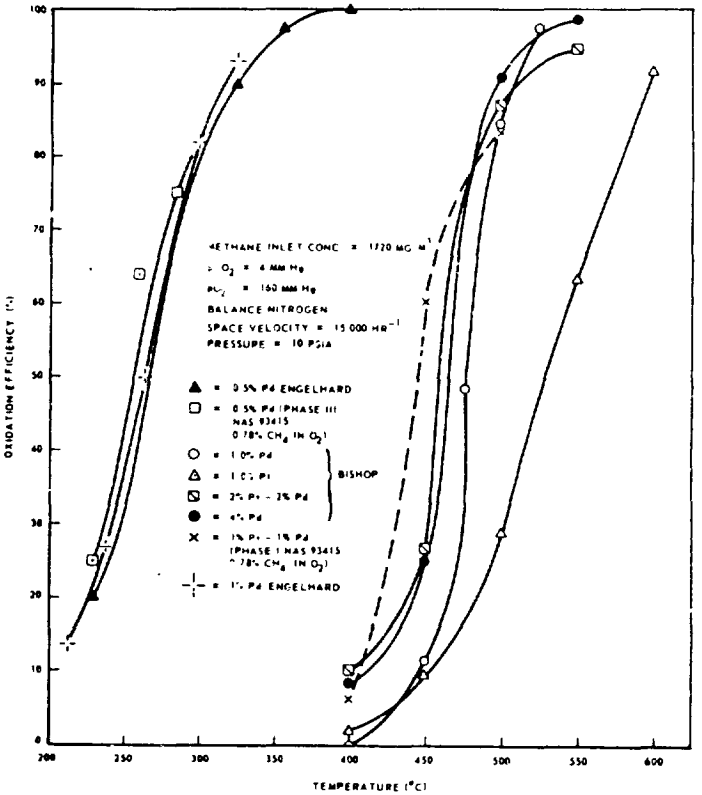
CATALYTIC OXIDIZER SIZING

- ESTABLISH CONTAMINANTS THAT REQUIRE OXIDATION FOR CONTROL
- DETERMINE NEED FOR HIGH OR LOW TEMPERATURE CATALYTIC OXIDIZER
- SELECT MOST EFFECTIVE CATALYST FROM TEST DATA
- DETERMINE FLOW RATE, RESIDENCE TIME AND CATALYST BED SIZE
- OPTIMIZE INSULATION REQUIREMENTS VERSUS BED SIZE

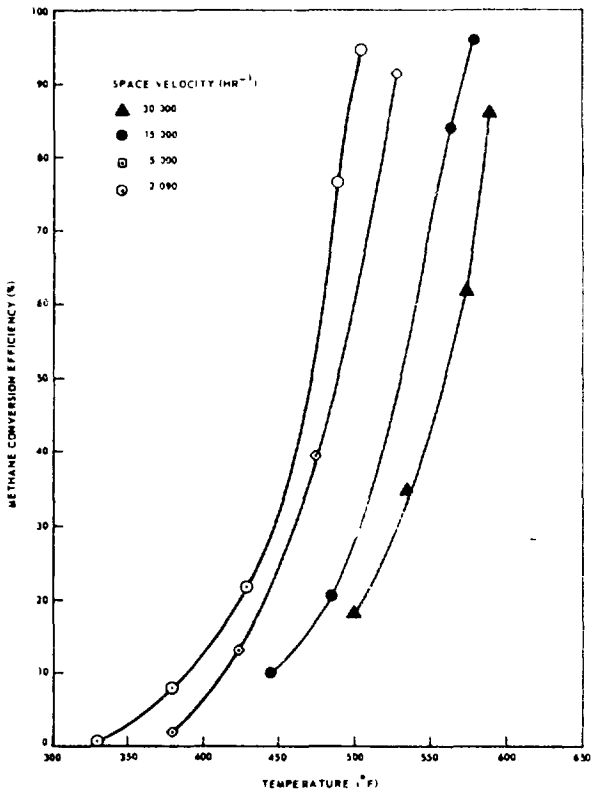
SPACE STATION PROGRAMS

TYPICAL CATALYTIC OXIDIZER PERFORMANCE CHARACTERISTICS

CONVERSION EFFICIENCY
FOR VARIOUS CATALYSTS



CONVERSION EFFICIENCY
FOR VARIOUS RESIDENCE TIMES



SPECIAL SORBENT BED SIZING

- USED FOR AMMONIA, ACID GASES AND OTHER SPECIAL CONTAMINANTS
- BED SIZE DETERMINED BY
  - ALLOWABLE CONCENTRATION
  - TOTAL CONTAMINANT GENERATION RATE
  - EXPERIMENTALLY DETERMINED CONTACT TIME
  - MISSION DURATION
- GENERALLY INTEGRATED INTO FIXED CHARCOAL BED
- LITHIUM HYDROXIDE AND POTASSIUM HYDROXIDE IMPREGNATED CHARCOAL USED FOR ACID GASES
- ACID IMPREGNATED CHARCOAL USED FOR AMMONIA
- CHROMATE IMPREGNATED CHARCOAL USED FOR FORMALDEHYDE

SPACE STATION PROGRAMS

ANIMAL AND PLANT RESEARCH PAYLOAD PROBLEMS

PROBLEMS

- o WASTE REMOVAL AND STORAGE
- o BACTERIOLOGICAL CROSS CONTAMINATION

SOLUTIONS

- o COMPLETE ISOLATION OF CREW AND EXPERIMENTS BY USE OF SEPARATE ENVIRONMENTAL SYSTEMS
- o USE OF HIGH EFFICIENCY BACTERIOLOGICAL FILTERS
- o USE OF ONLY SPF ANIMALS
- o USE OF ISOLATION TRANSPORTERS FOR WASTE REMOVAL AND STORAGE
- o USE OF SPECIALLY DESIGNED ISOLATION WORK STATIONS (GLOVE BOX DESIGN)

EMERGENCY UPSET CONTAMINANT REMOVAL

- SAFE HAVEN CREW SHELTER
- EMERGENCY CONTAMINANT REMOVAL SYSTEM REMOTELY ACTIVATED
- PORTABLE BREATHING APPARATUS
  - OXYGEN LINE
  - SUPEROXIDE BREATHER
- CABIN DECOMPRESSION AND REPRESSURIZATION

CONCLUSIONS

- TRACE CONTAMINANT CONTROL TECHNOLOGY BASE IS RELATIVELY FIRM
- HARDWARE AND DESIGN TOOLS ARE AVAILABLE
- PREVIOUS DESIGN PHILOSOPHY STILL APPLICABLE
  I.E., CONSERVATIVE LOAD MODEL REFINED LATER AS ACTUAL OFFGASSING DATA ARE AVAILABLE
- MAJOR CONCERNS
  - CATALYTIC OXIDIZER (NEED VS. DANGER)
  - CONTAMINANTS WITH VERY LOW ALLOWABLE CONCENTRATIONS
  - IMPACT OF RELAXING MATERIALS REQUIREMENTS

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